Attorney Docket No. 42390.P1901R

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Assistant Commissioner for Patents
Washington, D.C. 20231

REISSUE APPLICATION TRANSMITTAL

Transmitted herewith is the application for reissue of U.S. Patent No. 5,416,520 issued on May 16, 1995.

Inventor(s): Andrew J. Kuzma

Title: MULTIPLE ENCODER OUTPUT BUFFER APPARATUS FOR DIFFERENTIAL CODING OF VIDEO INFORMATION

Enclosed are the following:

1. Specification, Claim(s) and Drawings(s)

(a) 16 page(s) of specification, claims and/or abstract

(b) X 5 sheet(s) of drawings(s)
X formal
___ informal

No changes in the drawings upon which the original patent was issued are to be made. Therefore, in accordance with 37 CFR 1.174, please find attached, in the size required for original drawings:
X a copy of the printed drawings of the patent.
___ a photoprint of the original drawings.

2. Declaration and Power of Attorney

X 4 page(s) of declaration and power of attorney

3. Preliminary Amendment (check if applicable)

___ attached

4. Offer to Surrender the Original Letters Patent in Accordance With 37 CFR 1.178 is attached

X Offer to surrender is by the inventor (signed)
X along with assent of assignee (signed)
___ offer to surrender is by the assignee of the entire interest (and the reissue application does not seek to enlarge the claims of the original patent).

5. Letters Patent

___ original letters patent attached
___ declaration that original letters patent lost or inaccessible

6. Title

In accordance with 37 CFR 1.171 this application for reissue is accompanied by

__ a certified copy of an abstract of title
or
X an order for an abstract of title

7. Information Disclosure Statement (check if applicable)

__ attached

8. Fee Calculation (37 CFR 1.16(h), (i) and (j))

CLAIMS AS FILED

	Number Filed	Number Extra		Rate	Basic Fee	$770
Total Claims	20	0 (and also in excess of total claims in patent)	x	$22		$ 0
Independent Claims	6	3 (number of independent claims in patent)	x	$80		$240
		Filing Fee Calculation				$1,010

9. Method of Payment of Fees

X Enclosed is a check in the amount of $1,010.00.
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Date: 5/16/97

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Reissue Application No.:

Filed: Concurrently herewith

Patent No.: 5,416,520

Granted: May 16, 1995

Patentee: Andrew J. Kuzma

Title: MULTIPLE ENCODER OUTPUT BUFFER APPARATUS FOR DIFFERENTIAL CODING OF VIDEO INFORMATION

Commissioner of Patents
and Trademarks
Washington, D.C. 20231

REQUEST FOR ABSTRACT OF TITLE

1. Please prepare a certified Abstract of Title in respect of the above identified original patent for placing in the official file of the Reissue Application which is filed herewith.

2. (Complete the following, if applicable)

Title in the name of INTEL CORPORATION
was recorded on November 30, 1993, Reel 6798, Frame 0059.

3. For the fee required by 37 CFR 1.19(b)(4) please

X find enclosed a check in the amount of $25.00.
X charge any shortages or credit any overages to Account No. 02-2666.
A duplicate of this request is attached.
__ charge Account No. 02-2666 in the amount of $15.00.
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5-16-97

Attorney Docket No. 42390.P1901R

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Assistant Commissioner for Patents
Washington, D.C. 20231

REISSUE APPLICATION BY THE INVENTOR, OFFER TO SURRENDER (37 CFR 1.178)

The undersigned applicants of the accompanying reissue application for the reissue of letters patents for the improvement in **Multiple Encoder Output Buffer Apparatus For Differential Coding Of Video Information**

Patent No. 5,416,520 granted to him/her on May 16, 1995 of which
he/she is the sole owner
X Intel Corporation
now sole owner by assignment, and on whose behalf and with whose assent the accompanying application is made

hereby offers to surrender said letters patents.

Filed herewith is an
abstract of title, duly certified
X order for a title report
as required in such applications.

Dated: May 16, 1997

Andrew J. Kuzma

ASSENT OF ASSIGNEE TO REISSUE

The undersigned assignee of the entire interest in the above-mentioned letters patents, hereby assents to the accompanying application

Respectfully submitted,
BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN

Dated: 5/13/97

Carl L. Silverman
Director, Intellectual Property
Intel Corporation

Application For Reissue Of

U.S. Patent No. 5,416,520

of

Andrew J. Kuzma

for

MULTIPLE ENCODER OUTPUT BUFFER APPARATUS FOR DIFFERENTIAL CODING OF VIDEO INFORMATION

prepared by:

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Edith Fuentes
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United States Patent [19]

Kuzma

[54] **MULTIPLE ENCODER OUTPUT BUFFER APPARATUS FOR DIFFERENTIAL CODING OF VIDEO INFORMATION**

[75] Inventor: **Andrew J. Kuzma**, Portland, Oreg.

[73] Assignee: **Intel Corporation**, Santa Clara, Calif.

[21] Appl. No.: **159,665**

[22] Filed: **Nov. 30, 1993**

[51] **Int. Cl.**[6] **H04N 7/12**
[52] **U.S. Cl.** **348/409**; 348/384
[58] **Field of Search** 348/384, 400, 401, 409, 348/412, 423, 419; H04N 7/12

[56] **References Cited**

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Assistant Examiner—Richard Lee

MULTIPLE ENCODER OUTPUT BUFFER APPARATUS FOR DIFFERENTIAL CODING OF VIDEO INFORMATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the transmission of information over a communications path. More particularly, the present invention relates to the communications of high bandwidths information over networks of varying types.

2. Art Background

Until recently, telecommunications and computing were considered to be entirely separate disciplines. Telecommunications was analog and done in real time whereas computing was digital and performed at a rate determined by the processing speed of a computer. Today, such technologies as speech processing, electronic mail and facsimile have blurred these lines. In the coming years, computing and telecommunications will become almost indistinguishable in a race to support a broad range of new multimedia (i.e., voice, video and data) applications. These applications are made possible by emerging digital-processing technologies, which include: compressed audio (both high fidelity audio and speech), high resolution still images, and compressed video. The emerging technologies will allow for collaboration at a distance, including video conferencing.

Of these technologies, video is particularly exciting in terms of its potential applications. But video is also the most demanding in terms of processing power and sheer volume of data to be processed. Uncompressed digital video requires somewhere between 50 and 200 Mb/s (megabits per second) to support the real-time transmission of standard television quality images. This makes impractical the widespread use of uncompressed digital video in telecommunications applications.

Fortunately, there is considerable redundancy in video data, both in terms of information theory and human perception. This redundancy allows for the compression of digital video sequences into lower transmission rates. For some time, researchers have been aware of a variety of techniques that can be used to compress video data sequences anywhere from 2:1 to 1000:1, depending on the quality required by the application. Until recently, however, it was not practical to incorporate these techniques into low cost video-based applications.

A number of standards have been recently developed for such activities as video conferencing, the transmission and storage of standard high quality still images, as well as standards for interactive video playback to provide interoperability between numerous communications points. The standards recognize a need for quality video compression to reduce the tremendous amount of data required for the transmission of video information.

Two important methods of data compression for video information are used widely throughout the various standards for video communication. These are the concepts of frame differencing and motion compensation. Frame differencing recognizes that a normal video sequence has little variation from one frame to the next. If, instead of coding each frame, only the differences between a frame and the previous frame are coded, then the amount of information needed to describe the new frame will be dramatically reduced. Motion compensation recognizes that much of the difference that does

occur between successive frames can be characterized as a simple translation of motion, caused either by the moving of objects in the scene or by a pan of the field of view. Rather than form a simple difference between blocks in a current frame and the same block in the previous frame, the area around those blocks can be searched in the previous frame to find an offset block that more closely matches the block of the current frame. Once a best match has been identified, the difference between a reference block in the current frame and the best match in the previous frame are coded to produce a vector that describes the offset of the best match. This motion vector then can be used with the previous frame to produce the equivalent of what the current frame should be. These methods, and others are incorporated into systems which make possible the rapid transmission of real-time video information.

As the worlds of telecommunications and computers blend closely together, the telecommunications aspects of communications will have to contend with some of the constraints of the computer world. Particularly, video conferencing over existing computer networks will prove a challenge in that maintaining real time information communication over traffic-burdened existing network protocols may prove insurmountable.

Current video algorithms assume a nearly constant bandwidth availability for the encoding of video information. This is evidenced by the use of only a single output buffer for traditional video encoder output. It is common to use the output buffer fullness as a feedback parameter for encoding subsequent images; i.e., with higher or lower levels of quantization. A well-known effect resulting from using a single output buffer is called "bit-bang" where the output buffer is over depleted by the interface to the communications channel, causing the feedback loop to indicate that the buffer can handle lots of data, which in turn causes the video compression algorithm to under optimize the subsequent image coding. The user perceives the bit-bang as an uneven quality and frame rate.

To alleviate bit-bang, the typical approach has been to limit the amount of data pulled out from the encoder video output buffer to a fraction of the total size of the output buffer; 10% to 30% is typical. This approach keeps the feedback indicator rather small, and encoding more uniform. The underlying assumption of this approach is that the communications channel will usually not be changing rapidly. Exceptions are caused by connectivity interruptions, such as burst errors, which are handled strictly as exceptions to the call. In a local area network (LAN), or other collision-sensing multiple access channel, or in other networks with burst characteristics (such as noisy RF channels), this underlying assumption no longer holds. Over these sorts of communications channels, unanticipated transmission delays may result in bit-bang problems which are not so readily overcome by limiting the size of the feedback buffer. Thus, video jerkiness will result in real-time video communication over such channels. It would be advantageous, and is therefore an object of the present invention to provide a video transmission mechanism which can be accommodated on such potential bursty networks.

SUMMARY OF THE INVENTION

From the foregoing, it can be appreciated that there is a need for a mechanism of incorporating real-time video

data communication over traditional network protocols to smooth video transmission. It is therefore an object of the present invention to provide a method and apparatus for the conveyance of video data over such networks as local area networks.

These and other objects of the present invention are provided by introducing feedback between the video CODEC and the intended communications channel such that the characteristics of the channel are used to drive multiple video output buffers. These multiple output buffers share an original temporal video reference, but have different subsequent temporal video images. The communications channel interface then picks the subsequent video image buffer that best matches the current conditions experienced by it. By using a predictor of the channel performance, the video algorithm can be tuned to provide video output buffers with the best guess of how the buffers should be configured. A number of subsequent histories of an image are buffered until the receiving channel indicates it is ready to receive the next. Then the appropriate output buffer having the corresponding temporal change in the video is used to supply the next frame change information to the receiving station.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects, features and advantages of the present invention will be apparent from the following detailed description in which:

FIG. 1 demonstrate a hypothetical network having a plurality of video-capable nodes for interacting and providing video conferencing capabilities.

FIG. 2 illustrates hardware to be utilized in implementing the present invention in one embodiment.

FIG. 3 illustrates a logical rendition of a plurality of output buffers with successive time interval video information for one embodiment of the present invention.

FIG. 4 illustrates a branching tree structure corresponding to successive temporal transmit reference images for one embodiment of the present invention.

FIG. 5 illustrates alternative logical output buffer uses for channel dependent data transmission over a network.

FIG. 6 illustrates characteristics of audio information which may be transmitted over a network in accordance with another embodiment of the present invention.

FIG. 7 illustrates a generalized block diagram of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

A method and apparatus are described for the conveyance of real-time isochronous data over bursty networks. Although the present invention is described predominantly in terms of the transmission of video information, the concepts and method are broad enough to encompass the transmission of real-time audio and other data requiring isochronous data transfer. Throughout this detailed description, numerous details are specified such as bit rates and frame sizes, in order to provide a thorough understanding of the present invention. To one skilled in the art, however, it will be understood that the present invention may be practiced without such specific details. In other instances, well-known control structures and gate level circuits have not been shown in detail in order not to obscure unnecessarily the present invention. Particularly, some functions are

described to be carried out by various logic circuits. Those of ordinary skill in the art, having been described the various functions will be able to implement the necessary logic circuits without undue experimentation.

FIG. 1 is used to illustrate a simple network having a plurality of video-capable nodes. The network is illustrated as a simple star network 10 having a centrally incorporated multi-point control unit (MCU). The network is presented as having five (5) nodes 11, 12, 13, 14 and 15. For the purposes of explanation, these will all be considered video-capable nodes, with nodes 12 and 13 supporting IRV video (160 pixels×120 lines) while nodes 11, 14 and 15 support HQV video (320 pixels×240 lines). The network illustrated in FIG. 1 is purely for illustrative purposes and many more complex nodes may be incorporated that are non-video capable on the same network as the illustrated nodes. Further, the present invention may be applied to any network configuration besides the star configuration of FIG. 1 such as token ring networks, branching tree networks, etc. The fundamental requirement for the network which has these video-capable nodes is that the nodes be able to transmit data, including video data from one point to another and receive acknowledgments from the receiving node.

FIG. 2 illustrates typical video encoding hardware to which the present invention may be applied. This can be used for preparing video data to be transmitted over a network of the type illustrated in FIG. 1 to provide real-time video conferencing. A video camera 20 receives the video image that is to be encoded and conveyed. Such cameras are common and work on a number of technologies such as charge coupled devices, etc. The video camera may directly include video CODEC 21 or it may be tightly coupled as illustrated in the figure. The video CODEC 21 receives the electronic image from the camera and digitizes the image when being used in its encoder capacity. Video CODECS are generally known and come in a number of varieties which may be used for encoding video data to be transmitted and decoding video data when received. In FIG. 2, the camera output is propagated to the capture buffer 22 of video CODEC 21.

From the capture buffer 22, the video information is processed by motion estimation circuitry 23. The motion estimation circuitry is used to generate motion vectors which describe the difference of a portion of a video image from the previously recorded image in terms of a translational offset. The motion estimation circuitry compares the currently decoded frame from the previous frame stored in the transmit reference image buffer 30 about which more will be described further herein. From the motion estimation circuitry, the outputs are the motion vectors and the motion compensated image 24. The motion compensated image 24 is then processed by the differential pulse code modulation (DPCM) circuitry 25 which generates digital information of the changes to the previously stored transmit reference image. Finally, a final stage of coding is done at transform coding block 26 which also performs quantization and run-length encoding. Run-length encoding is a technique for compressing data sequences that have large numbers of zeros and is well-known to those of ordinary skill in the art. This transform coder may perform a discrete cosine transform (DCT).

From the transform coding block, the coded sequence is propagated to the output buffer 27 which is used to maintain a constant bit rate for the output to the

network. As was described, prior art methods used the output buffer fullness to regulate the degree of quantization that would be applied to the compressing and encoding circuitry because a constant bandwidth availability was assumed.

The transform coder block 26 also outputs the compressed image data to generate a new transfer reference image for storage in the transmit reference image buffer. The encoding logic provides the compressed image data to a decoding block 28 that has an inverse quantizer and inverse discrete cosine transform decoder which can be used to combine the decoded image data with the previously stored transfer reference image to yield a new transmit reference image which corresponds to the image that was most recently propagated on the network. It is this image data that would be used in calculating the changes in the image in sending the next frame of information. In other words, the transmit reference image, which is the same image that will be reconstructed at the other end by the video decoder, is used as the basis of subsequent encoding, including motion vectors and motion compensated image compression.

As was described in the previous section, the prior art feedback mechanism using the output buffer assumed a constant bit rate would be available for the transmission of information. This assumption no longer holds for video conferencing type devices which are on bursty networks such as CSMA LAN networks. The solution proposed by the present invention is to provide feedback between the video CODEC and the communications channel such that the characteristics of the channel are used to drive multiple video output buffers. These buffers share an original temporal video reference but will have different subsequent temporal video images. The communications channel interface then picks the subsequent video image buffer that best matches the current condition. By using a predictor of the channel performance, the video algorithm can be tuned to provide video output buffers with the best guess of how the buffers should be configured. Once a particular output buffer's image data is selected, the remaining buffers can be flushed to be refilled again based on a newly calculated transmit reference image. In the limit, the final action is to revert to an exception handler similar to current video CODECS, i.e., insert a key frame to restart the encoding of video data transmission.

FIG. 3 illustrates conceptually the logical multiple output buffers of the present invention. When the video camera 20 records an image it is encoded by the encoding circuitry described above and the encoded information is propagated to the output buffer 27. In a bursty network, the network may not be able to receive this newly calculated image data. Accordingly, the camera continues to detect images and encode the data and newly translated data is stored in subsequent output buffers such as 41, 42 or 43. For example, the information stored in the output buffer 27 may correspond to the digital information equivalent to the changes from the transmit reference image stored in the transmit reference image buffer 30 at time t=0. In output buffer 41, the data information may correspond to the difference between the transfer reference image and 1/15th of a second later than the data information stored in buffer 27. Likewise, output buffers 42 and 43 may store data corresponding to the temporal change between the

transmit reference image and the image before the camera at successively later times.

The video encoder and camera circuitry described may be incorporated as part of a station that is on the network and are responsive to information received over the communications channel. When a given node again has the bus, the output buffer with the most current image may be signaled to transmit its information to the receiving node. Likewise, the channel information is used to then calculate the next transmit reference image for storage. The output buffers are then flushed and are again loaded in a time sequential manner until the data is again ready to be sent over the network. While four (4) output buffers are illustrated, this is purely for illustrative purposes in that as many buffers may be implemented as computing power and resources provide.

FIG. 4 illustrates conceptually a branching tree that is pruned at times T=1, T=2, T=3, etc., for each slice of information that is taken and propagated on the network. This conceptualizes the use of multiple output buffers as a tree which is continually pruned with the most current pruning corresponding to the present transfer reference image.

FIG. 5 illustrates another conceptualization of the present invention. The encoder, through feedback from the data communications channel, creates several logical output buffers corresponding to behavioral predictions based on the feedback from the communications channel. For example, logical output buffer 1 could represent the case where more bandwidth will be dynamically allocated to this natural data compression over the next unit of time. The unit of time could be an image frame or, for example, a frame of sampled audio. In FIG. 5, the various predictions of the bandwidth available to the compression algorithm are shown below in Table I.

TABLE I

Logical Output Buffer	Prediction of Bandwidth per Unit Time Relative to Current Transmit Reference
1	about the same
2	a lot more
3	more
4	a lot less

For video coding, more bandwidth could be used to get sharper images and/or higher frame rate. The actual data contained in the logical output buffers can be significantly different, too. For example, in video coding, the new transmit reference might be calculated from different input images in time and/or spatial resolution. Logical output buffer 1 might represent the data from an image taken 1/15th of a second later than transmit reference 0, while logical output buffer 2 might represent the differential coding from an image half a second later from transmit reference 0. Such an approach would be good for video coding for channels where the bit rate allocated to video may undergo extreme fluctuations such as in the bursty networks described above.

While with reference to FIGS. 2 and 3, the output buffers are illustrated as, for example, discrete memory elements. FIG. 5 makes it clear that logical buffers may be created in a common block of memory and that the number of such buffers is limited only by the available computational power to simultaneously encode them and the memory to sufficiently handle them. FIG. 6 is

used to illustrate that the present invention is not necessarily limited to video encoding and illustrates a frame of audio information. For example, in the G.728 standard each frame of data is 5 milliseconds long. The frame may be stored as a transmit reference and subsequent transmissions may follow the differential coding principals wherein only the changed information is sent to the receiving node. The audio encoder may be responsive to feedback from the network and maintain a plurality of logical output buffers such as those described in the video application. One possible application for such an implementation would be in wireless telephony wherein portions of an audio transmission may be lost when a transmitting station goes through a tunnel. The responding network indicates that its most recently received information is slightly stale and that a late change logical output buffer should be used in providing the encoded differential information.

In a more general description of the present invention, reference is now made to FIG. 7. Information about a real-time object **100** that is desired to be conveyed from a transmitting node to a receiving node on some sort of network is shown. This real-time object **100** may be a video image or it may be a sound depending on the particular implementation. A capture mechanism **110** detects the real-time object and encodes it into electronic information. The capture mechanism may be a camera for video information as described above or a microphone or stereo microphones for audio information. This information is then processed by differential encoder **115** which compares the newly captured real-time object to the previously stored recorded object in transmit reference buffer **120**. The differentially encoded data is then propagated to a logical output buffer **125** which operates as those described above. When the network clears the output buffers for transmission, the particular output buffer having the best information conveys it over the network and that same information is used to calculate a new transmit reference to be stored in transmit reference buffer **120**.

There has thus been described a method and apparatus of differential coding for use in bursty transmission networks which greatly improves the quality of transmitted compressed information. Although the present invention has been described in terms of preferred embodiments, it will be appreciated that various modifications and alterations might be made by those skilled in the art without departing from the spirit and scope of the invention. The invention should, therefore, be measured in terms of the claims which follow.

What is claimed is:

1. For use in a communications network having a plurality of nodes wherein a node may encode real-time information for propagating over said network, a method of processing said real-time information comprising the steps of:

providing said node with a plurality of output buffers;

(a) electronically capturing said real-time information and converting it into electronic data;

(b) differentially encoding said electronic data using a previously stored transmit reference image as a base to produce differential data;

(c) storing said differential data in one of said plurality of output buffers;

(d) monitoring said network for access to propagate said differential data;

repeating steps (a)–(d) until said node may propagate said differential data over said network;

transmitting data over said network from the one of said plurality of output buffers providing a best differential data to a receiving node on said network, wherein said best differential data represents a differential data whose use in conjunction with the previously stored transmit reference image produces an image that approximates a current frame better than use of other differential data contained in said plurality of output buffers; and

calculating a new transmit reference image based on said best differential data and said previously stored transmit reference image.

* * * * *

SUB A1

2. An apparatus comprising:

an encoder for producing encoded real-time information;

a transmit reference buffer for storing a current transmit reference;

compression circuitry coupled to the encoder and to the transmit reference buffer for producing compressed data based upon the current transmit reference and the encoded real-time information;

a plurality of output buffers coupled to the compression circuitry for storing the compressed data; and

a network interface coupled to the plurality of output buffers, the network interface for interfacing with a network, for determining a selected output buffer from the plurality of output buffers and for transmitting data over the network from the selected output buffer, the selected output buffer containing compressed data which accommodates one or more characteristics of the network better than at least compressed data in another buffer of the plurality of output buffers.

3. The apparatus of claim 2, wherein the selected output buffer contains compressed data which accommodates one or more characteristics of the network better than compressed data in all other buffers of the plurality of output buffers.

SUB A2

4. An apparatus for transmitting real-time information over a network, the apparatus comprising:

an encoder for producing encoded real-time information;

a transmit reference buffer for storing a current transmit reference;

compression circuitry coupled to the encoder and to the transmit reference buffer for producing compressed data based upon the current transmit reference and the encoded real-time information; and

a plurality of output buffers coupled to the compression circuitry for buffering the compressed data, each of the plurality of output buffers having a contents, the contents of a selected output buffer of the plurality of output buffers to be transmitted onto a data communications channel of a network based upon one or more characteristics of the data communications channel.

5. The apparatus of claim 4 further comprising a network interface coupled to the plurality of output buffers, the network interface for interfacing with the network, the network interface determining the selected output buffer and transmitting data over the network from the selected output buffer.

6. The apparatus of claim 5, wherein the selected output buffer contains compressed data which, when used in conjunction with the current transmit reference, accommodates the one or more characteristics of the data communications channel better than compressed data from at least another buffer of the plurality of output buffers.

7. The apparatus of claim 5, wherein the selected output buffer contains compressed data which, when used in conjunction with the current transmit reference, accommodates the one or more characteristics of the data communications channel better than compressed data from all other buffers of the plurality of output buffers.

8. The apparatus of claim 4, wherein the compressed data comprises a differential between the encoded real-time information and the current transmit reference.

9. The apparatus of claim 4, wherein the one or more characteristics of the data communications channel include bandwidth availability on the data communications channel.

10. The apparatus of claim 4, wherein the one or more characteristics of the data communications channel include burstiness of traffic on the data communications channel.

11. The apparatus of claim 4, wherein the one or more characteristics of the data communications channel include transmission delay on the data communications channel.

12. The apparatus of claim 4, wherein the encoded real-time information includes video information.

13. The apparatus of claim 4, wherein the encoded real-time information includes audio information.

14. An apparatus for transmitting real-time information over a network, the apparatus comprising:
an encoder for producing encoded real-time information;
a transmit reference buffer for storing a current transmit reference;
compression circuitry coupled to the encoder and to the transmit reference buffer for producing compressed data based upon the current transmit reference and the encoded real-time information; and
a plurality of output buffers coupled to the compression circuitry, the plurality of output buffers for storing the compressed data to be transmitted onto the network from one of the plurality of output buffers.

15. An apparatus comprising:
an encoder for producing encoded real-time information;
a transmit reference buffer for storing a current transmit reference;

compression circuitry coupled to the encoder and to the transmit reference buffer for producing compressed data based upon the current transmit reference and the encoded real-time information;

a plurality of output buffers coupled to the compression circuitry for storing the compressed data; and

a network interface coupled to the plurality of output buffers, the network interface for selecting a selected output buffer of the plurality of output buffers by determining, with reference to one or more predetermined coding strategies, whether compressed data from the selected output buffer is appropriate for transmission to a receiving node.

16. The apparatus of claim 15, wherein the one or more predetermined coding strategies include minimizing artifacts.

17. The apparatus of claim 15, wherein the one or more predetermined coding strategies include allocating available bandwidth to achieve a higher frame rate.

18. An apparatus comprising:

an encoder for producing encoded real-time information;

compression circuitry coupled to the encoder for producing compressed data based upon a previously stored transmit reference and the encoded real-time information;

a plurality of output buffers coupled to the compression circuitry for storing the compressed data; and

a network interface coupled to the plurality of output buffers, the network interface transmitting compressed data from a selected output buffer of the plurality of output buffers, the compressed data from the selected output buffer when used in conjunction with the previously stored transmit reference approximating a next frame expected by a receiving apparatus.

19. A method of transmitting data over a network comprising the steps of:

encoding the data by determining the differences between the data and a transmit reference to produce differential data;

storing the differential data in one of a plurality of output buffers;

selecting one of the plurality of output buffers as a current transmit buffer based upon one or more characteristics of a data communications channel of a network; and

transmitting differential data from the current transmit buffer over the network.

SUB A3

20. A method of transmitting real-time data over a network comprising the steps of:

encoding the real-time data by determining the differences between the real-time data and a transmit reference to produce differential data;

storing the differential data in one of a plurality of output buffers;

selecting one of the plurality of output buffers as a current transmit buffer by determining whether the differential data in a particular transmit buffer accommodates the one or more characteristics of the network better than differential data in at least another buffer of the plurality of output buffers; and

transmitting differential data from the current transmit buffer over the network.

Added

US005416520A

[11] **Patent Number: 5,416,520**

[45] **Date of Patent: May 16, 1995**

Attorney, Agent, or Firm—Blakely, Sokoloff, Taylor & Zafman

[57] **ABSTRACT**

Feedback is introduced between a video CODEC and the intended communications channel such that the characteristics of the channel are used to drive multiple video output buffers. These multiple output buffers share an original temporal video reference, but have different subsequent temporal video images. The communications channel interface then picks the subsequent video image buffer that best matches the current conditions experienced by it. By using a predictor of the channel performance, the video algorithm can be tuned to provide video output buffers with the best guess of how the buffers should be configured. A number of subsequent histories of an image are buffered until the receiving channel indicates it is ready to receive the next. Then the appropriate output buffer having the corresponding temporal change in the video is used to supply the next frame change information to the receiving station.

1 Claim, 5 Drawing Sheets

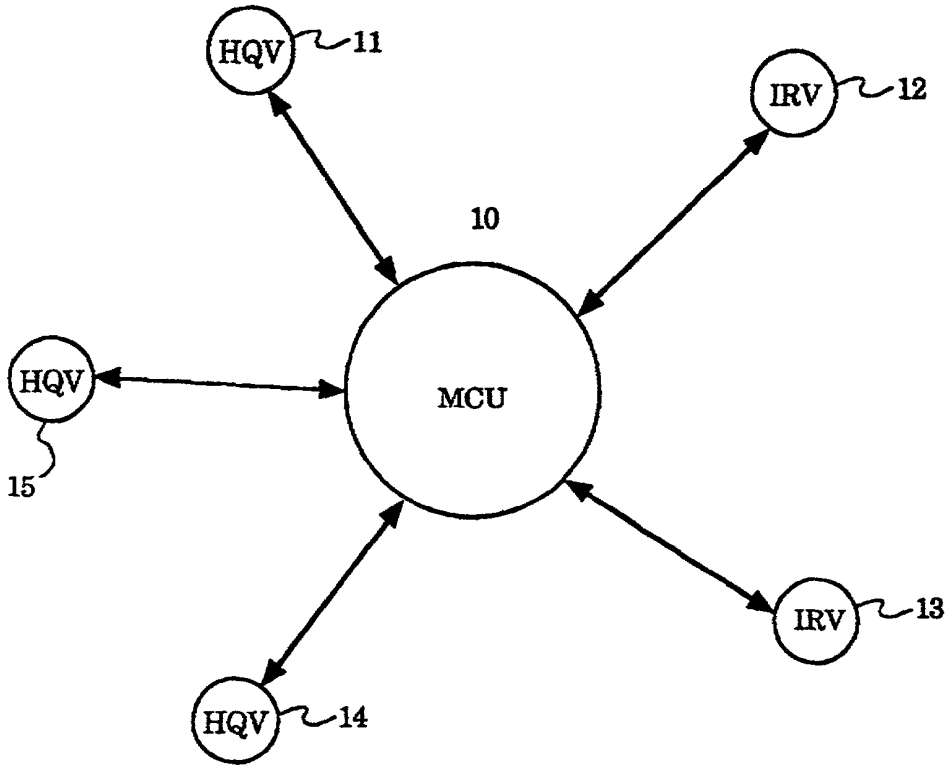

Figure 1

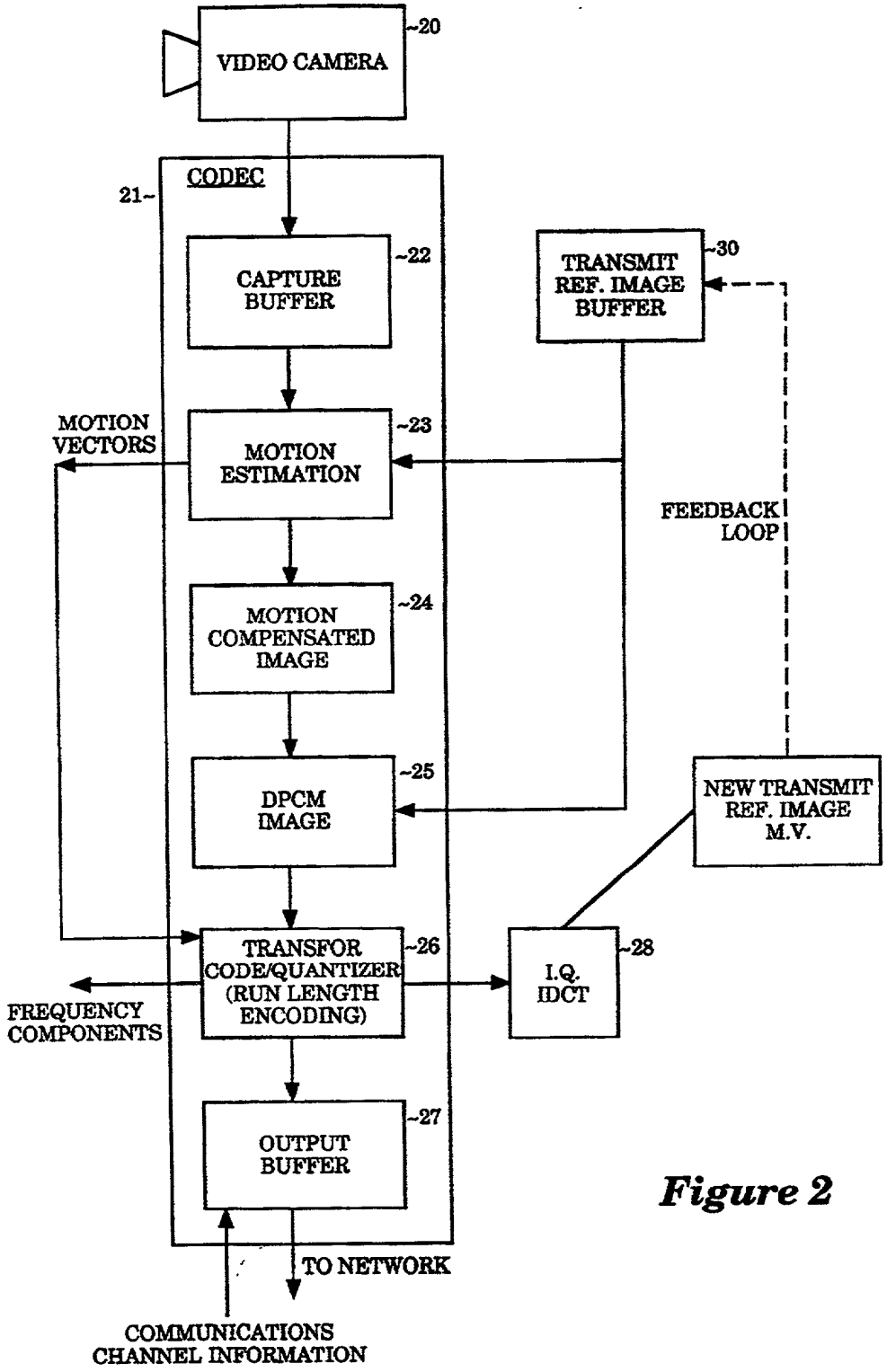
VIDEO CAMERA
20
CODEC
21
CAPTURE BUFFER
22
TRANSMIT REF. IMAGE BUFFER
30
MOTION VECTORS
MOTION ESTIMATION
23
FEEDBACK LOOP
MOTION COMPENSATED IMAGE
24
DPCM IMAGE
25
NEW TRANSMIT REF. IMAGE M.V.
TRANSFOR CODE/QUANTIZER (RUN LENGTH ENCODING)
26
I.Q. IDCT
28
FREQUENCY COMPONENTS
OUTPUT BUFFER
27
TO NETWORK
COMMUNICATIONS CHANNEL INFORMATION

Figure 2

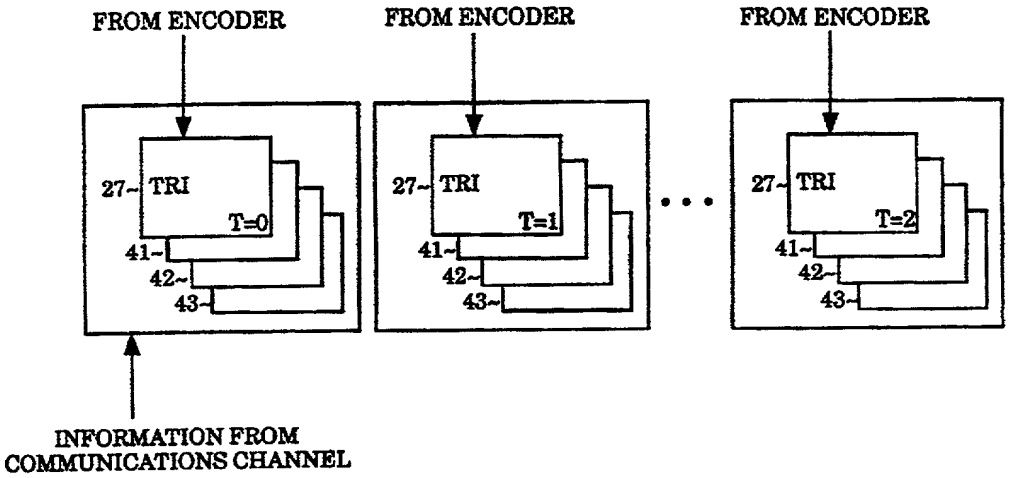

Figure 3

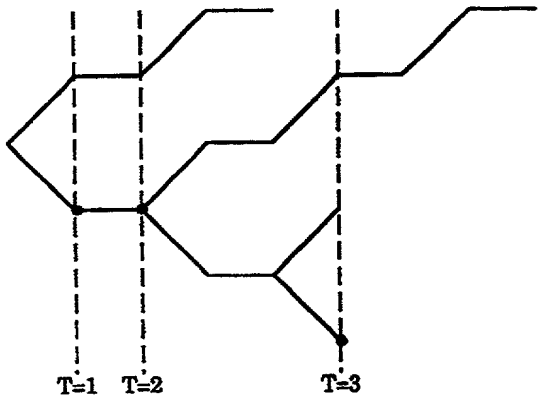

Figure 4

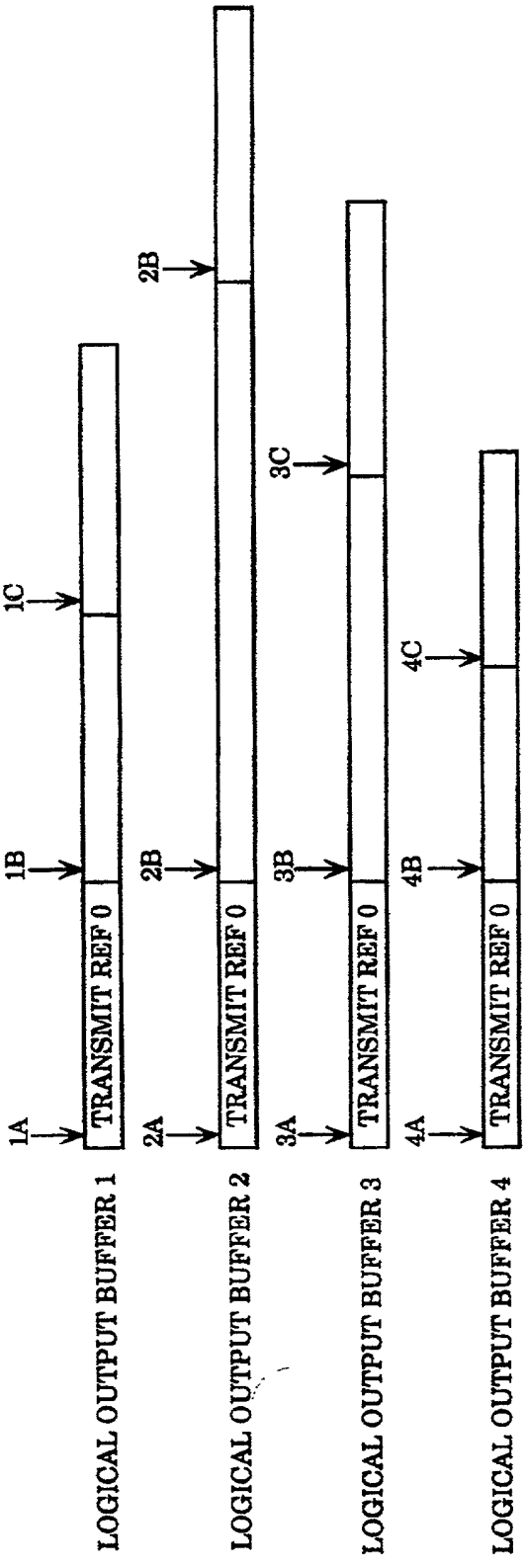

Figure 5

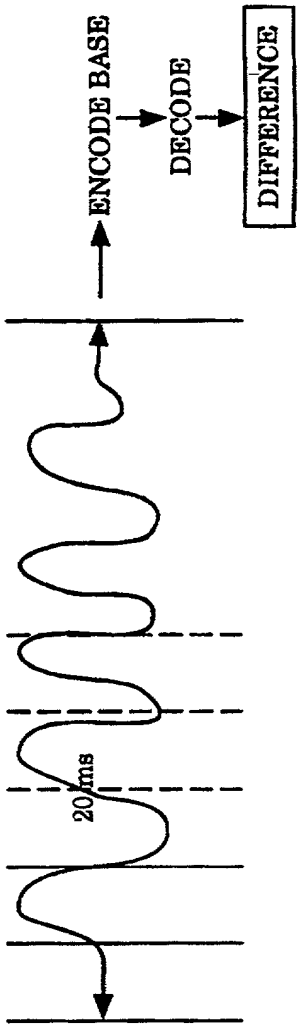

Figure 6

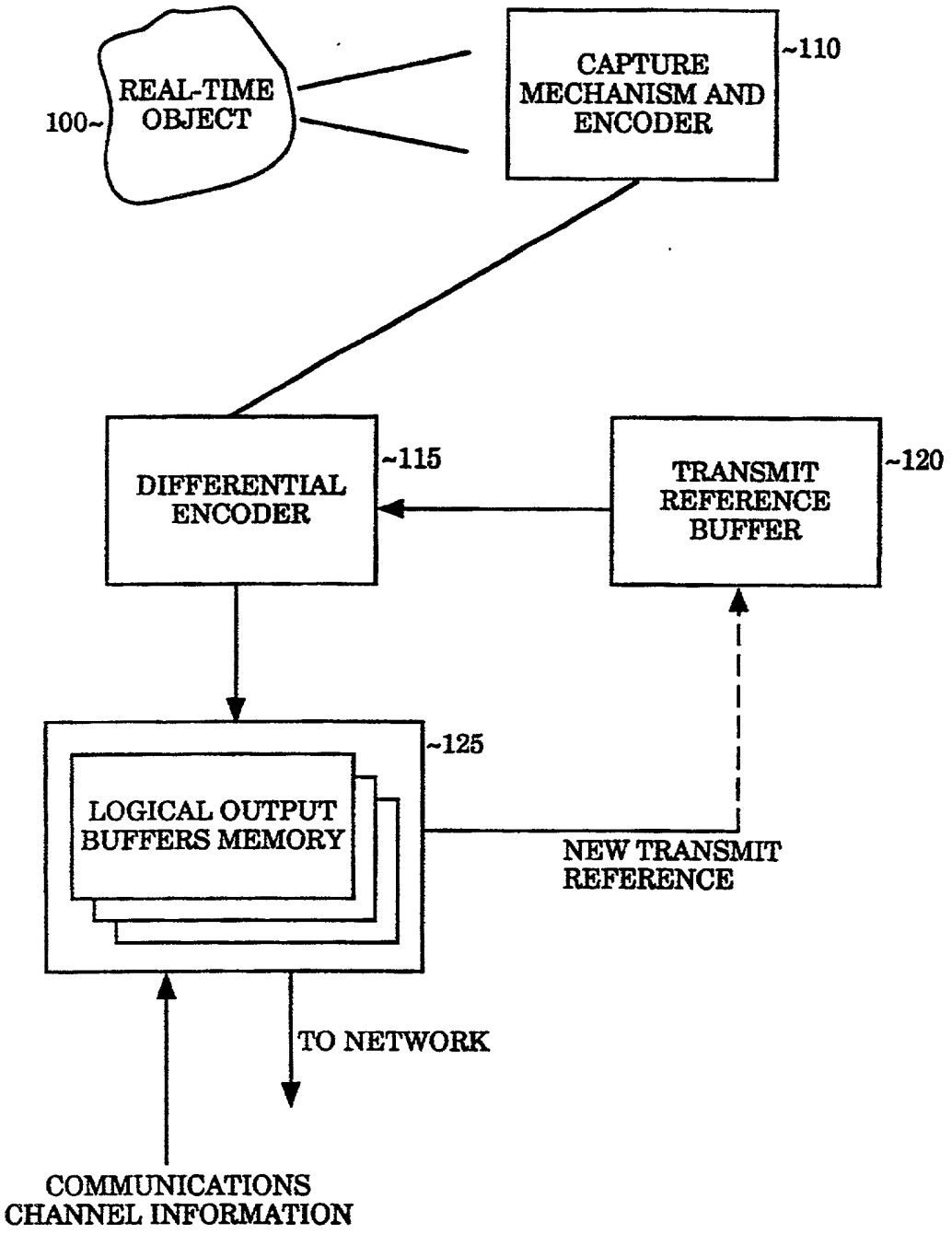
REAL-TIME OBJECT
100~
CAPTURE MECHANISM AND ENCODER
~110
DIFFERENTIAL ENCODER
~115
TRANSMIT REFERENCE BUFFER
~120
LOGICAL OUTPUT BUFFERS MEMORY
~125
NEW TRANSMIT REFERENCE
TO NETWORK
COMMUNICATIONS CHANNEL INFORMATION

Figure 7

Attorney's Docket No.: 042390.P1901R Patent

DECLARATION AND POWER OF ATTORNEY FOR REISSUE PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

MULTIPLE ENCODER OUTPUT BUFFER APPARATUS FOR DIFFERENTIAL CODING OF VIDEO INFORMATION

the specification of which is attached hereto and was issued as U.S. Patent No. 5,416,520 (the "original patent") from application number 159,665, filed November 30, 1993 (the "original application").

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I do not know and do not believe that the claimed invention was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to the original application, that the same was not in public use or on sale in the United States of America more than one year prior to the original application, and that the invention has not been patented or made the subject of an inventor's certificate issued before the date of the original application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (for a utility patent application) or six months (for a design patent application) prior to the original application.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

Rev. 04/01/96 (D1) cak

"Express Mail" mailing label number: EM564111586US
Date of Deposit: May 16, 1997
I hereby certify that I am causing this paper or fee to be deposited with the United States Postal Service "Express Mail Post Office to Addressee" service on the date indicated above and that this paper or fee has been addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231

EDITH FUENTES
(Typed or printed name of person mailing paper or fee)

(Signature of person mailing paper or fee)

5-16-97
(Date signed)

I hereby claim the benefit under title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below

(Application Number)	Filing Date

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Number)	Filing Date	(Status -- patented, pending, abandoned)
(Application Number)	Filing Date	(Status -- patented, pending, abandoned)

I hereby appoint Aloysius T. C. AuYeung, Reg. No. 35,432; William Thomas Babbitt, Reg. No. 39,591; Jordan Michael Becker, Reg. No. 39,602; Bradley J. Bereznak, Reg. No. 33,474; Michael A. Bernadicou, Reg. No. 35,934; Roger W. Blakely, Jr., Reg. No. 25,831; Gregory D. Caldwell, Reg. No. 39,926; Kent M. Chen, Reg. No. 39,630; Lawrence M. Cho, Reg. No. 39,942; Thomas M. Coester, Reg. No. 39,637; Roland B. Cortes, Reg. No. 39,152; William Donald Davis, Reg. No. 38,428; Michael Anthony DeSanctis, Reg. No. 39,957; Daniel M. De Vos, Reg. No. 37,813; Karen L. Feisthamel, Reg. No. 40,264; James Y. Go, Reg. No. P-40,621; Tarek N. Fahmi, Reg. No. P-41,402; David R. Halvorson, Reg. No. 33,395; Eric Ho, Reg. No. 39,711; George W Hoover II, Reg. No. 32,992; Eric S. Hyman, Reg. No. 30,139; Dag H. Johansen, Reg. No. 36,172; Stephen L. King, Reg. No. 19,180; Dolly M. Lee, Reg. No. 39,742; Michael J. Mallie, Reg. No. 36,591; Kimberley G. Nobles, Reg. No. 38,255; Ronald W. Reagin, Reg. No. 20,340; James H. Salter, Reg. No. 35,668; William W. Schaal, Reg. No. 39,018; James C. Scheller, Reg. No. 31,195; Charles E. Shemwell, Reg. No. 40,171; Maria McCormack Sobrino, Reg. No. 31,639; Stanley W. Sokoloff, Reg. No. 25,128; Allan T. Sponseller, Reg. No. 38,318; Steven R. Sponseller, Reg. No. 39,384; Edwin H. Taylor, Reg. No. 25,129; Lester J. Vincent, Reg. No. 31,460; John Patrick Ward, Reg. No. 40,216; Ben J. Yorks, Reg. No. 33,609; and Norman Zafman, Reg. No. 26,250; my attorneys; and Robert Andrew Diehl, Reg. No. P-40,992; Sharmini Nathan Green, Reg. No. P-41,410; Thomas A. Hassing, Reg. No. 36,159; Edwin A. Sloane, Reg. No. 34,728; and Judith A. Szepesi, Reg. No. 39,393; my patent agents, of BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP, with offices located at 12400 Wilshire Boulevard, 7th Floor, Los Angeles, California 90025, telephone (310) 207-3800, and Joseph R. Bond, Reg. No. 36,458; Richard C. Calderwood, Reg. No. 35,468; Sean Fitzgerald, Reg. No. 32,027; Naomi Obinata, Reg. No. 39,320; Thomas C. Reynolds, Reg. No. 32,488; Howard A. Skaist, Reg. No. 36,008; and Raymond J. Werner, Reg. No. 34,752; my patent attorneys, of INTEL CORPORATION with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

I verily believe the original patent to be wholly or partially inoperative by reason that the patent claims less than I had a right to claim in the patent. The claim contains excess limitations not necessary for patentability. For example, the claim contains excess limitations not necessary for distinguishing over the prior art. Also, the claim fails to cover embodiments of the invention as claimed in the above-identified reissue application. The error arose during the drafting of the original application and during subsequent amendments in connection with the prosecution of the original application which resulted in the issuance of the patent. The attorney prosecuting the original application failed to appreciate the scope of the invention, and thus limited the claims as indicated above. The error arose without any deceptive intention on my part. I further acknowledge my duty to disclose information which is material to the examination of the application under 37 CFR § 1.56.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of Sole/First Inventor Andrew J. Kuzma 1-00

Inventor's Signature _____ Date _____

Residence Portland, Oregon OR Citizenship USA
(City, State) (Country)

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Portland, Oregon 97229

Title 37, Code of Federal Regulations, Section 1.56
Duty to Disclose Information Material to Patentability

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclosure information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information

which is not material to the patentability of any existing claim. The duty to disclosure all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) Prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) The closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made or record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application;

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.